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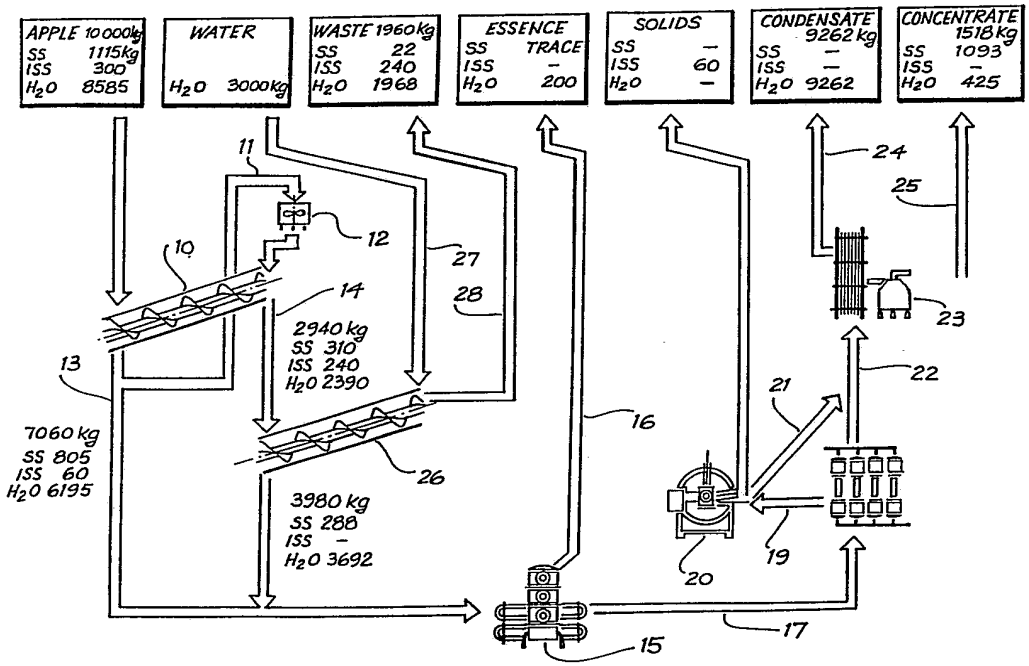
(54) Title: ENZYMATIC EXTRACTION OF FRUIT AND VEGETABLES



(57) Abstract

Juice is extracted from fruit such as apples by passing the sliced fruit through a counter current extractor in counter current with an aqueous extracting liquid containing a pectolytic enzyme. The addition of pectolytic enzyme to the extracting liquid increases the total yield of juice from the fruit and may allow the juice to be obtained with less dilution.

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ENZYMATIC EXTRACTION OF FRUIT AND VEGETABLES

Technical Field

The present invention relates to a method for the processing of fruit and vegetables and to products prepared by that method. In particular the present invention relates to a method of processing fruit to obtain fruit juice.

Background Art

It is known in the prior art to use pectolytic enzymes in the processing of apple and other fruit in the production of fruit juices. However, up until recently these enzymes have been used in relation to extracted, pressed juice or partly concentrated juice. The role of these enzymes has been to degrade soluble pectin and thus reduce viscosity allowing easier clarification and higher concentration of the juice.

More recently, pectolytic enzymes have been used to treat the mash of apples and other fruits prior to pressing to assist in the release of free juice. Mash is finely macerated fruit tissue in which most of the cells have been ruptured to release the cytoplasm. The use of enzymes in this process results in an increased yield in comparison with the traditional process of merely pressing. Typically the addition of enzyme will increase the yield from a single press system from about 70% to 80% and from a double press system with pomace washing from about 80% to 88%.

The enzyme is added to the mash after milling and before pressing and its addition is generally metered carefully. The mash is then allowed to stand for a period of time, typically about sixty minutes.

It is also known in the prior art to extract juice from fruit by diffusion using a counter current extractor. This extraction process typically yields 93% to 98% of available juice without the use of enzymes. One

drawback typically encountered with juice obtained using prior art counter current extraction methods is that the concentration of soluble solids in the product may be relatively low. This limits further processing options as there are a number of standards with respect to the concentration of soluble solids in the product which must be met.

Disclosure of the Invention

The present invention consists in a method of processing fruit or vegetables comprising steps of :-

(1) slicing the fruit or vegetables,

(2) passing the sliced fruit or vegetable in counter current with an aqueous liquid in a counter current extractor, the aqueous liquid comprising a solution of pectolytic enzyme(s), and

(3) recovering a liquid phase from the lower end of the counter current extractor and a solid phase from the upper end of the counter current extractor.

While the present invention is hereinafter discussed with reference to the processing of apples it will be appreciated that the present invention could be applied to a wide variety of fruits such as pears, mangoes, guavas, peaches and pineapples and to some vegetables such as cucumbers and chokos.

The advantage of the preferred embodiments of this invention can be seen in the following table which shows the yield and dilution of apple juice obtained by a variety of methods including the method according to this invention.

EXTRACTION TECHNIQUE	YIELD	DILUTION
Pressing only	70%	---
Pressing with Pomace Washing	85%	23%
Pressing with Enzyme and Pomace Washing	90%	20%
Diffusion Extraction	95%	20%
Diffusion Extraction with Continuous Enzyming according to preferred embodiments of this invention	98%	6%

In a preferred embodiment of the present invention the aqueous liquid is fruit or vegetable juice containing the pectolytical enzyme(s). Preferably the fruit or vegetable juice used as the counter flowing stream has the same level of soluble solids as the sliced fruit or vegetable to be processed.

In a further preferred embodiment of the present invention the solid phase recovered from the upper end of the counter current extractor is transferred to a second counter current extractor where it is passed in counter current with an aqueous liquid, preferably water. A second liquid phase is recovered from the lower end of the second counter current extractor and this may be dosed with pectolytic enzyme(s) and used as the aqueous liquid in the first counter current extractor. In this case, of course, the product from the first counter current extractor will be to some extent diluted relative to normal single strength juice.

In a yet further preferred embodiment of the present invention the aqueous liquid used in the first counter current extractor is at a temperature of about 50 - 55^{o}C. Due to the elevated temperature it is preferred that the pectolytic enzymes used are

thermophylic. A single pectolytic enzyme may be used in the aqueous solution or a mixture of a number of such enzymes may be so used.

The best concentration of enzyme can be determined for any given processing condition and equipment by simple trials however enzyme concentrations from 100 to 1000 ppm of the aqueous liquid, and preferably 500 ppm, are preferred.

The fruit or vegetable slices may be subjected to counter current in any known type of counter current extractor. It is, however, highly preferred that the extraction is carried out in a counter current extractor as described in U.S. patent specification No. 4,363,264, the contents of which are incorporated herein by reference. The fruit or vegetable slices are fed into the lower end of a channel shaped trough and are moved up the trough in a counter current with the aqueous liquid containing pectolytic enzyme(s).

The liquid and solid phases are recovered from the counter current extractor in the usual way. The liquid phase or serum contains a large proportion of the aroma and flavour components of the fruit. This liquid phase is preferably fractionated in a spinning cone column, a still or other volatile component recovery apparatus to separate the volatile aroma component. The remaining solution of flavour compounds, generally salts and sugars, may be concentrated in the normal manner such as through reverse osmosis and/or an evaporator.

The processes according to at least the preferred embodiments of the present invention have a number of advantages over the known prior art processes. These preferred processes results in :-

(1) The extraction of 97-99% of the soluble solids present in the fruit,

(2) The capacity of the diffusion equipment being

increased by 30-50%,

(3) Reduction in the level of dilution of the liquid phase recovered and a consequent reduction in the cost of water removal,

(4) The production of one product stream which is substantially undiluted product and a second product stream which is a highly diluted product. This allows the processor greater flexibility in his use of the products,

(5) A decrease in the overall process time.

As stated above, one advantage achieved by use of the method of the present invention, when the counter current liquid containing the enzyme is fruit juice, is that the liquid phase obtained from the first counter current extractor contains soluble solids from the fruit in an undiluted form. For example when apples are processed by the method of the present invention about 70% of the soluble solids are obtained in the liquid phase recovered from the first counter current extractor. This is standard single strength apple juice. This higher concentration of soluble solids greatly increases the options available for further processing. If the counter current liquid containing the enzyme(s) is water or a dilute solution of fruit juice then of course the resultant product will be more dilute than the undiluted fruit juice produced as described above. There are, however, circumstances in which the production of larger quantities of diluted juice are advantageous.

As would be understood by a person skilled in the art for a particular product to be referred as "fruit juice" it must contain a certain concentration of soluble solids from that fruit. The production of a liquid phase having a high concentration of soluble solids is a distinct advantage of the present invention.

Brief Description of the Drawing

Hereinafter given by way of example only is a

preferred embodiment of the present invention described with reference to the accompanying drawing which shows in Fig. 1 diagramatically the steps in the process and the mass transfer associated with each of these steps.

Best Mode of Carrying Out the Invention

Example 1

Apples are sliced in a conventional slicer (not shown) which results in less than 1% of the cell walls being ruptured, the remainder remaining intact and the cells organised.

The slices fall directly into the lower end of a counter current extractor 10, generally as described in U.S patent specification No. 4,363,264 and are moved therethrough in counter current with a stream 11 of apple juice heated to approximately 50-55°C and to which a pectolytic enzyme has been added. The juice recycle stream 11 is introduced in the upper end of the counter current extractor 10 through a spray nozzle 12.

As the slices are conveyed up the counter current extractor 10 against the juice recycle stream 11 including the enzymes, the enzymes are intimately contacted with and diffuse into the slices. By virtue of their pectolytic action the enzymes perforate the cell walls releasing approximately 70% of the cytoplasm containing the soluble flavour and aroma compounds i.e. the juice. The slices comprising the insoluble solids collapse and are discharged at the upper end as a solid phase stream 14.

The liquid phase stream 13 is directed to a spinning cone column 15 made as described in Australian patent specification No. 53350/86 (the contents whereof are hereby incorporated herein by reference). The volatile essence is recovered as a final product stream 16 with or without concentration. The underflow 17 from the spinning cone column 15 is passed through a filtration apparatus 18 to remove any suspended solids. The solid phase stream 19

from the filtration apparatus 18 is fed to a rotary vacuum filter 20.

A liquid stream 21 from the rotary vacuum filter 20 is combined with a fluid stream 22 from the filtration apparatus 18. This fluid stream is passed to multi stage plate evaporator 23 to concentrate the liquid. The evaporator 23 produces a water condensate stream 24 and a flavour concentrate stream 25.

The solid phase stream from the first counter current extractor 10 is fed to a second counter current extractor 26. The counter current extractor 26 is generally as described in US patent specification No. 4,363,264.

The solid phase stream 14 is conveyed up to the counter current extractor 26 against a counter current flow 27 of water. The soluble solids in the solid phase stream 14 diffuse into the liquid stream 27 and provide apple juice stream 11. The insoluble solids are discharged at the upper end as a solid phase stream 28.

Example 2

Materials and Method

Delicious apples were purchased from the Flemington markets, Sydney, via Statewood Foods. The purchases were over a period of approximately 2 weeks, however the fruit was of similar quality even though it came from different growers.

The counter current extractor was run using half an hour retention time. The operating parameters were the same for each trial and are given in Table 1.

Table 1

Operating Parameters

T. Forward	30.3 sec	Angle	5°
T. Reverse	24.2 sec	Pause F/R	1.0 sec
RPM Forward	3.0 sec	Pause R/F	1.0 sec
RPM Reverse	3.0 sec	Feed Rate	12 Kg/hr

Enzyme Addition - Mid point of trough

All solids were sliced in a Halde Type RG-1-PAT Slicer using a 3mm Crinkle cut blade.

The experiments compared the recovery of juice with and without the use of pectolytic enzyme and varied the following parameters:

(a) Temperature setting

(b) Extraction solvent

The enzyme used was Pectinex Ultra SP-L, Batch 300 and came from Novo Ferment (Switzerland) Ltd.

The enzyme was made up by adding 10ml of Pectinex to 200ml of water and adding 10ml of this mixture to the extractor every 5 minutes. This dosing was equivalent to 500ppm of enzyme with respect to solids fed.

The trials on the apples, which had a Brix value of 15°, were performed as follows:

(a) Variation of Temperature

60°C setting: no enzyme -2 hour run, water stopped with last feed

enzyme -2 hour run, water and enzyme stopped with last feed

This temperature setting gave an actual temperature of 43° at the bottom of the counter current extractor and 53°C at the top of it.

70°C setting:	no enzyme	-1 1/2 hour run, water stopped with last feed
	enzyme (500ppm)	-1 1/2 hour run, water and enzyme stopped with last feed

This temperature setting gave an actual temperature of 50° at the bottom of the counter current extractor and 61° at the top of it.

(b) Variation of Solvent

No enzyme	-2 hour run, extraction juice from above experiment (no enzyme). Water stopped with last feed.
Enzyme (500ppm)	-1 1/2 hour run, extraction juice from above experiment (enzyme). Water stopped with last feed.

This experiment was conducted at a temperature setting of 75°C.

Where the experiments have slight variation, for example when the extraction water was stopped after the last feed, allowances have been made in the results.

The discharged solids contained an amount of excess liquid which was drained off via a wire mesh screen.

Results and Discussions

The mass balances and sugar contents for the various trials are given in Tables 2 and 3. For convenience the solids feed has been taken as 1 unit in each case and the extraction water or juice, the recovered juice and the recovered solids have been represented as a multiple of the solids feed.

Table 2

Variations in Temperature

	RUN 1	RUN 2	RUN 3	RUN 4
Solids feed	1 unit	1 unit	1 unit	1 unit
Solids feed % of feed sugar	100%	100%	100%	100%
Extraction water	1.2units	1.2units	1.2units	1.2units
Enzyme concentration	-	500 ppm	-	500 ppm
Temperature setting	60°C	60°C	70°C	70°C
Juice	0.8units	1.68units	1.02units	1.51units
Juice % of feed sugar	63%	71%	63%	79%
Drained solids	0.78units	0.42units	0.67units	0.4units
Drained solids % of feed sugar	N/A	N/A	17%	19%

Table 3

Use of Extraction Juice as Solvent

	RUN 1	RUN 2
Solids feed	1 unit	1 unit
Solids feed % of feed sugar	100%	100%
Extraction juice	1.2unit	1.1units
Extraction juice sugar content as % of feed sugar	80%	57%
Enzyme concentration	NIL	500 ppm
Temperature setting	75°C	75°C
Juice	.99units	1.46units
Juice % of feed sugar	88%	114%
Drained solids	.84units	0.56units
Drained solids % of feed sugar	62%	38%

In all cases trials with enzymes gave an increase in juice production. However, the sugar content in the juices that had been treated with enzyme was lower, i.e. increased dilution. The enzyme addition caused the apples to collapse to quite a noticeable extent, especially in the top end of the trough.

The discharged solids were quite 'mashed up' in appearance, even though they conveyed well during the extraction. In general, the solids from the enzyme trials were less in weight but had a higher sugar content compared with the solids from the trials without enzyme addition.

From Table 2 there seems to be little effect from varying the temperature setting of the counter current extractor. However, there are other variables that could have influenced these results. The 70°C trial was a one and a half hour run where as the 60°C trial was a two hour run. This may have meant that a steady-state wasn't achieved for long enough, even though the trials lasted twice the retention time generally considered adequate.

A temperature setting gave a temperature profile along the trough which is inherent to the present equipment configuration. The temperature profiles in the trough will affect the activity and stability of the enzyme. Temperature also affects diffusion rates within the cells.

Juice from the temperature trials was used as the extraction solvent in Table 3. As there might have been active enzyme in the juice from these trials, appropriate juices were used. Again the juice volume increased and had a higher yield but it was more dilute.

It will be recognised by persons skilled in the art that numerous variations and modifications may be made to the invention as described above without departing from the spirit or scope of the invention as broadly described.

CLAIMS:

1. A method of processing fruit or vegetables comprising steps of :-

(1) slicing the fruit or vegetables,

(2) passing the sliced fruit or vegetable in counter current with an aqueous liquid in a counter current extractor, the aqueous liquid comprising a solution of pectolytic enzyme(s), and

(3) recovering a liquid phase from the lower end of the counter current extractor and a solid phase from the upper end of the counter current extractor.

2. A method as claimed in claim 1 in which the aqueous liquid is the juice of a fruit or vegetable to which has been added a pectolytic enzyme.

3. A method as claimed in claim 2 in which the aqueous liquid is the juice of the fruit or vegetable being processed.

4. A method as claimed in any one of claims 1 to 3 in which the solid phase recovered from the upper end of the counter current extractor is transferred to a second counter current extractor where it is passed in counter current with an aqueous liquid and a second liquid phase is recovered from the lower end of the second counter current extractor.

5. A method as claimed in claim 4 in which the second liquid phase to which a pectolytic enzyme has been added is used as the aqueous liquid.

6. A method as claimed in claim 1 in which the pectolytic enzyme is a thermophylic enzyme.

7. A method as claimed in claim 6 in which the aqueous liquid is at a temperature of from 50 to 55°C.

8. A method as claimed in claim 1 in which the pectolytic enzyme is present in the aqueous liquid in a concentration of from 100 to 1000 ppm.

9. A method as claimed in any one of claims 1 to 8 in which the method is carried out on slices of apple.

10. A liquid phase derived from the processing of fruit or vegetables by a method as claimed in any one of claims 1 to 9.

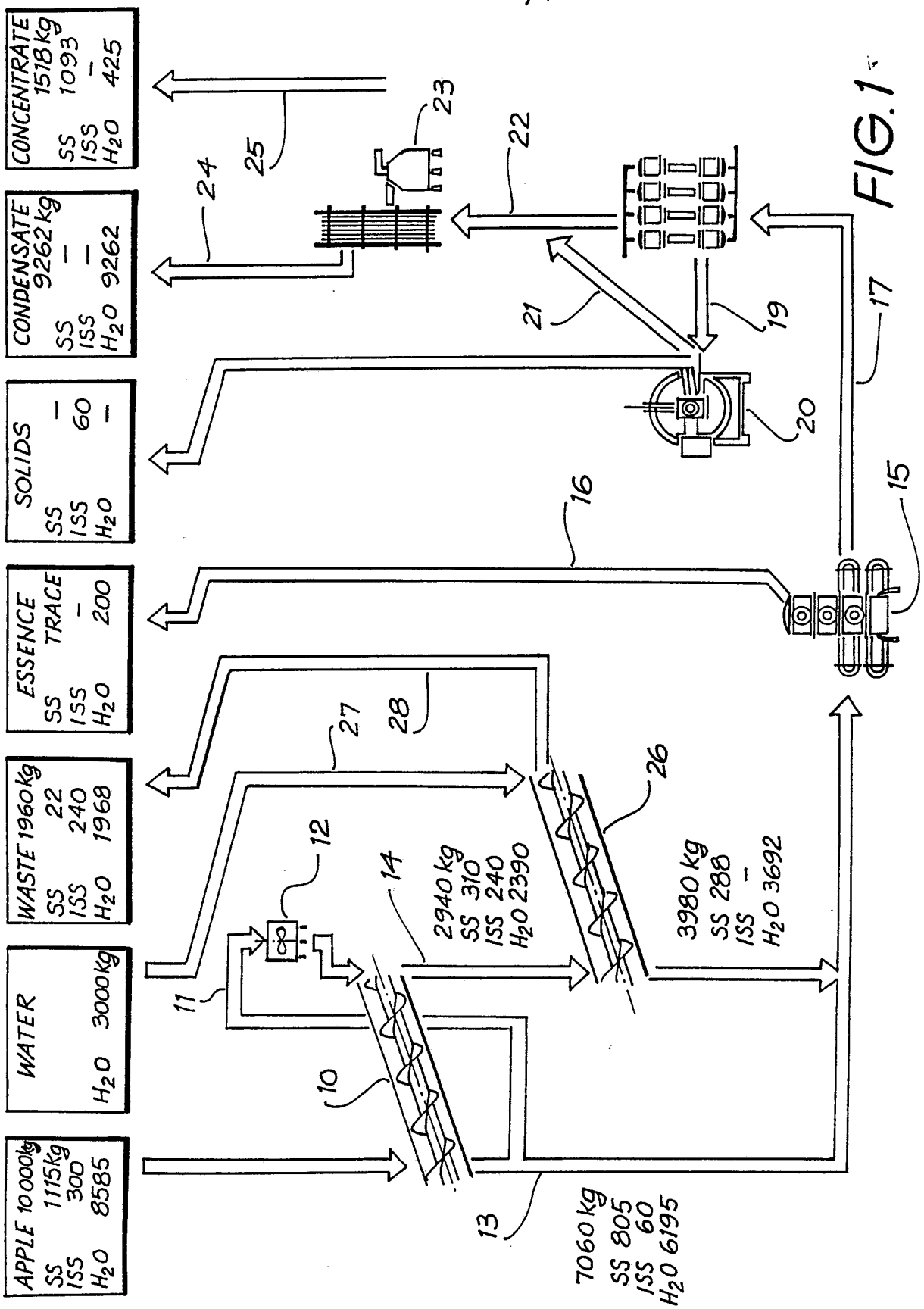

FIG. 1

SUBSTITUTE SHEET

INTERNATIONAL SEARCH REPORT

International Application No. PCT/AU 89/00497

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) 6

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl.[4] A23L 2/04, 1/212

II. FIELDS SEARCHED

Minimum Documentation Searched 7

Classification System	Classification Symbols
IPC	A23L 2/04, 2/06 and keyword ENZYM:, A23L 1/212
US	426/50

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched 8

AU: IPC as above, Australian Classification 34.720

III. DOCUMENTS CONSIDERED TO BE RELEVANT 9

Category*	Citation of Document,[11] with indication, where appropriate, of the relevant passages 12	Relevant to Claim No 13
X	AU,B, 12030/76 (495090) (BUCHER-ULRICH AG MASCHINENFABRIK) 22 September 1977 (22.09.77) See page 5 paragraph 2, page 7 paragraph 2, and claim 8	(1-5)
A	AU,A, 47996/85 (BIOQUIP AUSTRALIA PTY LIMITED) 10 April 1986 (10.04.86)	(1)
A	US,A, 4363264 (LANG) 14 December 1982 (14.12.82)	(1)
A	AU,B, 23858/77 (505069) (SOCIETE DES PRODUITS NESTLE SA) 5 October 1978 (05.10.78)	(1)
A	AU,B, 44011/79 (522196) (TOYO SEIKAN KAISHA LIMITED) 16 August 1979 (16.08.79)	(1)

* Special categories of cited documents: 10

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
15 February 1990 (15.02.90)	22 February 1990 (22.02.90)
International Searching Authority	Signature of Authorized Officer
Australian Patent Office	S.J. YONG

Form PCT/ISA/210 (second sheet) (January 1985)

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON
INTERNATIONAL APPLICATION NO. PCT/AU 89/497

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report	Patent Family Members		
AU 12030/76	AR 212588	BG 30764	CH 584603
	CS 191293	DE 2606987	HU 174268
	PL 101096		
AU 47996/85	ES 547592	ES 8703085	US 4873095
US 4363264	CA 1158840	AT 3014/81	BR 8104283
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	JP 54107544	US 4275648	US 4353096
	JP 54113461	DE 2940487	GB 2035747
	JP 55134573	JP 55049069	

END OF ANNEX

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DOCUMENT-IDENTIFIER: WO 9005463 A1

TITLE: ENZYMATIC EXTRACTION OF FRUIT AND VEGETABLES

PUBN-DATE: May 31, 1990

INVENTOR-INFORMATION:

NAME	COUNTRY
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NAME	COUNTRY
COUNTER CURRENT TECHNOLOGY PTY	AU

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INT-CL (IPC): A23L001/212 , A23L002/04

EUR-CL (EPC): A23L002/04

US-CL-CURRENT: 426/50

ABSTRACT:

CHG DATE=19990617 STATUS=O>Juice is extracted from fruit such as apples by passing the sliced fruit through a counter current extractor in counter current with an aqueous extracting liquid containing a pectolytic enzyme. The addition of pectolytic enzyme to the extracting liquid increases the total yield of juice from the fruit and may allow the juice

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